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ABSTRACT

This paper describes a domain-specific repository based on the methodology for e-learning systems development. The methodology, which is based on information engineering and object-oriented technology, is used to support navigation for courseware development, designing the curriculum of e-learning components, and e-learning resources management. A repository-based approach is key to the support of e-learning development and reuse of e-learning resources such as application frameworks and components. Through the structure of the repository such as meta-model/model/object-base and by use of object-oriented modeling, it is constructed for reuse by systems and models for their target system. Subject matter experts can develop their courseware by reusing models and object bases for their e-learning. By using Common Object Request Broker (CORBA) architecture, the authors developed the distributed e-learning systems development environment. (Contains 13 references.) (Author)

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The Methodology for Reuse of E-Learning Resources

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ABSTRACT: This paper describes a domain-specific repository based on the methodology for e-learning systems development. The methodology, which is based on information engineering and object-oriented technology, is used to support navigation for courseware development, designing the curriculum of elearning components, and elearning resources management. A repository-based approach is key to support of elearning development and reuse of elearning resources such as application frameworks and components. Through the structure of the repository such as meta-model / model / object-base and by use of object-oriented modeling, it is constructed for reuse by systems analysts and subject matter experts. Systems analysts can build new models by reusing meta-model and models for their target system. Subject matter experts can develop their courseware by reusing models and object bases for their e-learning. And, by using CORBA architecture, we developed the distributed e-learning systems development environment.

1. Introduction

The reuse of instructional materials is developed by some projects such as ARIADNE (ARIADNE , 2001) and SCORM (SCORM, 2001). The purpose of this paper is to present the methodology for the reuse of e-learning resources such as components (included instructional materials) and application frameworks. For the systems analyst, Repository-Based Environment for Computerized Courseware Analysis (REBECCA) (Fuji 1997) enables the reconstruction of e-learning systems by reusing application frameworks such as Audio Visual and Adaptive Learning system by Oneself in Network (AVALON) (Fuji *et al.*, 1994) and Collaborative and Multimedia Environment for Learners on Teams (CAMELOT) (Fuji *et al.*, 1996). For the subject matter expert, WWW-based Curriculum Authoring with Thesaurus (WEB-CAT) (Fuji and Hoshihara, 1997) enables the construction of the intended curriculum with collaborative work through WWW, while REBECCA provides a means of course navigation, the reuse of instructional material, and target system generation.

There are two learning styles incorporated in e-learning systems: individual learning environment, and collaborative learning environment. We have developed prototypes of an application framework, AVALON (for the individual learning environment) and CAMELOT (for the collaborative learning environment). These application frameworks are constructed by use of object-oriented technology, and are stored in the domain specific repository called REBECCA for reuse. Repository-based methodology is derived from information engineering (Martin, 1989). With regard to the components in e-learning systems, there are instructional material, curriculum, and pedagogy. We have developed a prototype called WEB-CAT for developing curriculum through collaborative work with a domain specific repository and WWW. And, as the REBECCA is constructed by an object-oriented technology, it is easy to adapt Common Object Request Broker (CORBA). E-learning components and e-learning frameworks of the distributed REBECCA correspond to a CORBA application object, and these components use CORBA services for searching for distributed object reference by name or for creating new objects.

This paper is organized into two sections: Section 2 outlines the framework in e-learning systems; Section 3 describes the distributed e-learning systems development environment with CORBA architecture.

2. Framework and Component for E-Learning

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The reuse approach is based upon and relies on the concepts that reusable software components are produced and stored in a repository. There are two main types of object-oriented components:

(1) solution-based inheritance hierarchies, and
(2) domain-based frameworks

This framework is based on domain-based frame works such as CAI systems, and we use a framework in the sense of a skeleton application that the developer can adjust with it. The term "component" is often used interchangeably. The software component is a physical packaging of executable software with a well-defined and published interface (Hopkins, 2000). The following definition of "component" will be used in this section: "core elements that compose an application framework."

2.1. Methodology for E-Learning Systems Development with Repository

In software engineering, structured techniques are applied to one project, whereas in information engineering, structured techniques are applied to the enterprise as a whole or to a large sector of the enterprise. Information engineering techniques encompass those of software engineering in a modified form. Information engineering has been defined with reference to automated techniques as follows: an interlocking set of automated techniques in which enterprise models, data models and process models are built up in a repository and are used to create and maintain data-processing systems. The repository is a key technology in information engineering, and it steadily accumulates information relating to the planning, analysis, design, construction and, later, the maintenance of systems.

The field of instructional design was initiated by the United States Department of Defense during World WarII to improve the efficiency of certain types of high level technical training programs such as pilot training (Reiser, 1987). The systems approach is a step-by-step procedure for solving problems. It has been applied to educational problems at all levels, from education in general, to training for a specific target population. In instructional design, the systems approach is sometimes referred to as instructional systems development. There are numerous models demonstrating this approach. Although the models differ in detail, such as the number and sequence of steps in which specific components are grouped, the common basic steps are grouped into the following five categories: analysis, design, production, implementation, and evaluation.

The methodology of REBECCA is based on that of information engineering and instructional design. The characteristics of this methodology are as follows.

- Object-oriented repository for managing e-learning systems resources
- Reuse for e-learning systems framework
  individual learning, collaborative learning
- Reuse for e-learning systems components
  instructional material, curriculum, pedagogy
- Navigation for courseware development
  analysis, design, construction

2.2. E-Learning Frameworks

The e-learning frameworks used are: AVALON for the individual learning environment and CAMELOT for the collaborative learning.

AVALON

The AVALON e-learning framework is a multimedia intelligent tutoring system. The system provides adaptive instructional units and pedagogy suited to the individual learner's understanding. The system also provides multimedia instructional units, such as video, voice, text, and image data, suited to each individual learner's characteristics. This framework, composed of pedagogy, a learner model and instructional material information, was used as a base. In order to adapt the following two functions, i.e., a function for dynamic representation of multimedia instructional material corresponding to the comprehension level of each learner and to the media characteristics, and a function for interactive response to questions from learners, we developed an instructional object in which the multimedia instructional material and knowledge expression of instructional material were encapsulated as an instructional object.

CAMELOT

The CAMELOT e-learning framework is a collaborative learning support system. The learning process is based on a nominal group technique. The system facilitates collaborative learning navigation, group discussion, and remedy of collaborative work solutions. The pedagogy is a combination of rule-based reasoning and case-based reasoning. The system can remedy learner's basic mistakes using rule-based reasoning. And also case-based reasoning can present analogous solutions to learners for deeper understanding. In the business systems design environment, there may be more than one solution to any given problem. For example the data model will be different depending on the perspective of each individual leaner.

Thus, collaborative learning systems are very effective in this domain. By using CAMELOT, each learner learns how to analyze through case study and how to cooperate with his or her group in problem solving. Learners come to a deeper understanding from using CAMELOT than from studying independently, because of shared discussion, tips from other learners, and examinations, and review of one another's works.

2.3. E-Learning Components

As domain specific components in elearning systems, there are the instructional object, curriculum object, and pedagogy object that compose e-learning application framework.

Instructional Object

An instructional object is an extended instructional unit. An instructional object is composed of a multimedia object and a knowledge object. A multimedia object incorporates multimedia instructional material, such as text, image, voice, and video. A knowledge object incorporates the knowledge representation of instructional units, such as semantic network, rule-based reasoning, and case-based reasoning. An instructional object is used for components when subject matter experts design courseware.

Curriculum Object

A curriculum object is related to instructional objects and selected by pedagogy objects. A curriculum object is structured using a thesaurus. This object is composed of a superordinate concept, a subordinate concept, and related concepts.

Pedagogy Object

A pedagogy object is composed of three tiers such as planning strategy, learning strategy, and action objects for strategy. The basic concept of the learning strategy is based on Gagné's accumulated learning model (Gagné, 1985). The learning strategy is composed of "problem solving", "rule learning", "concept learning", "multiple discrimination learning", "verbal association", "chaining", "stimulus-response learning", and "signal learning". Subject matter experts can design their pedagogy for CAI systems by combining these pedagogy objects.

3. Distributed Environment with Repository

Since the Internet is used worldwide, the global learning environment is also changing to incorporate use of the Internet. In many types of organizations, such as universities and private enterprises, subject matter experts are developing various types of courseware; each site can be connected to the network and they can find a variety of courseware. However, they are not able to use courseware for reuse, because the various types of courseware are developed and executable from different platforms such as Pentium, PowerPC, SPARC, and so on. For the common use of the courseware through the Internet, the distributed heterogeneous development environment is required.

3.1. Utilization of Distributed Object Technology

CORBA is an industry-wide standard for creating distributed object systems. It is a standard that is accessible from many different languages and allows interoperability on various platforms. Using CORBA, a client object can transparently invoke a method on a server object, which can be on the same machine or across a network. CORBA intercepts the call and is responsible for finding an object that can implement

the request, pass on to it the parameters, invoke its method, and return the results. The client does not have to be aware of where the object is located, its programming language, or its operating system.

From these characteristics of CORBA, we developed a distributed development environment REBECCA using CORBA. CORBA provides the following benefits in development of distributed development environment:

- CORBA supports many programming language mapping
- CORBA supports distributed computing and object orientation
- CORBA provides interoperability between different vendor's ORBs

3.2. Distributed Repository Using CORBA

As the REBECCA is constructed by an object-oriented technology, it is easy to adapt CORBA. Object Management Architecture (OMA) has four major components, ORB (Object Request Broker), CORBA services, CORBA facilities, and application objects. ORB is a communication infrastructure between distributed objects. CORBA services are a set of system service interface, and include the naming service and the persistent service.

CORBA facilities represent specifications in great detail for the construction of the distributed system. E-learning components of the distributed REBECCA correspond to a CORBA application object, and these components use CORBA services for searching distributed object reference by name or for creating new objects. E-learning frameworks (such as AVALON and CAMELOT) correspond to CORBA facilities that provide domain dependent services. At each site, there is a repository object stored e-learning component such as instructional objects, curriculum objects, and pedagogy objects. The repository object manages the other objects and communicates with the repository object of another site in order to obtain information from and access to resources at another site (Figure 1). The distributed REBECCA with CORBA provides the following functions:

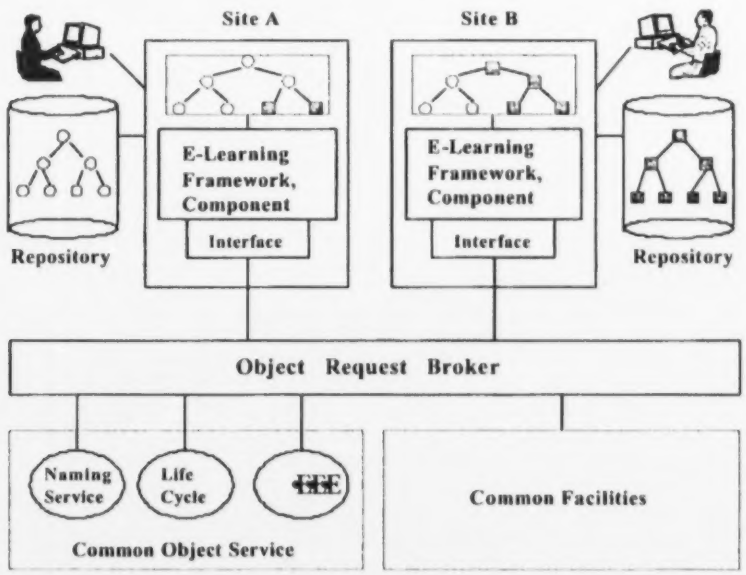

Figure 1: Distributed Development Environment with CORBA

Enables the reuse of heterogeneous and distributed e-learning components

The distributed REBECCA provides methods to treat heterogeneous distributed e-learning components uniformly, so that subject matter experts are able to reuse these elearning components in developing courseware. E-learning systems can provide adaptive instructional objects on the network.

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Appropriate site of e-learning components

In using CORBA environment, implementation of e-learning components is encapsulated and can be placed at the distribution site, according to the characteristics of each e-learning component. Therefore, e-learning components can be placed in the appropriate sites. For instance, an instructional object that includes simulation material, which requires a large amount of computer power, is placed at a high performance computer site, and the pedagogy object that requires high inference performance is placed at a computer site with high performance engine for inference.

Management for distributed e-learning components

The distributed repository manages each e-learning components stored in each server site. The distributed e-learning components are able to maintain consistency by means of a global instruction manager (Tanigawa *et al.*, 1998).

4. Conclusion

In this paper, we have described a methodology for e-learning systems development and a domain specific repository for reuse of e-learning framework and e-learning component. The repository is the key to supporting e-learning systems development and reusing e-learning systems resources. Using a three-level structure, such as meta-model, model, object-base, and using object-oriented modeling, REBECCA provides for ease of reuse for systems analysts and subject matter experts. It further enables construction of a distributed e-learning systems development environment using CORBA architecture.

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